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THE FEASIBILITY OF USING
BIOMASS FOR FUEL
AT THE UNIVERSITY OF MONTANA

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MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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THE FEASIBILITY OF USING BIOMASS FOR FUEL AT THE UNIVERSITY OF MONTANA

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October 1985

Prepared for

Montana Department of Natural Resources and Conservation
1520 East 6th Avenue, Helena, Montana 59620
Biomass Utilization and Cogeneration Program
Grant Agreement Number ED-BS-733

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ABSTRACT:

A legal and environmental study was conducted to determine the feasibility of burning wood to heat UM. Woodburning technology is such that the process can be done with essentially zero emission of carbon monoxide (CO) or particulates. This was a critical finding since Missoula exceeds Environmental Protection Agency (EPA)-set CO levels at certain times of the year. It would be politically impossible for UM to install a system that would emit particulates no matter how safe those particulates might be.

Two alternatives were selected for detailed study: 1) conversion of an existing boiler and 2) the construction of a new cogeneration plant. The energy demand pattern at UM and the fact that a boiler conversion would not permit cogeneration of electricity leads to the conclusion that a new boiler with cogeneration capability is the preferred alternative.

The Lubrecht Experimental Forest (LEF) has a supply of biomass that could if necessary pro-vide fuel for fifteen years. This estimate does not include wood that would grow during those fifteen years. An alternative to total supply from LEF is suggested; LEF should supply one quarter of the annual demand and UM should purchase the other three-fourths from state and private non-industrial owners. This arrangement would assure a continuous supply and spread economic benefits to others. With supply coming from two sources, a more stable market and price structure would result.

BIOMASS COGENERATION AT THE UNIVERSITY OF MONTANA

LEGAL AND ENVIRONMENTAL FEASIBILITY

The critical element in this program was the determination of whether or not it was legally and environmentally feasible to burn wood in large quantites in Missoula and stay within legal, social, and environmental constraints. New woodburning technology improves almost daily, making it a realistic alternative. Five years ago it is unlikely that biomass cogeneration would have been possible.

The details of the search of legislation and regulations are in Appendix A of this report. The system installed must not emit CO and particulates. Nitrous Oxides (NOx) are not produced in biomass burning. Missoula does not comply with EPA standards for CO levels during part of the year (early-and mid-winter) and a facility that would worsen that problem would not be permitted. Furnace technology has now made available a number of boilers that have zero CO and particulate emissions.

The key point to be made is this: only a system that has essentially zero emission of carbon monoxide and particulates is environmentally and legally acceptable. With new technology it is possible to build such systems to burn woody biomass such as that whch can come from second growth forests in the Missoula area. The existence of that technology for zero CO and particulate emission is cited in the letter of transmittal of Milestone 1 of this report.

THE EXISTING SYSTEM

The UM presently has three natural-gas fired boilers; two with capacities of 70 thousand pounds per hour (kpph), and one with 30 kpph. Normal demand (load) requires only one boiler to be in operation. During cold weather a 70 kpph boiler is operated, and the other 70 kpph is held in reserve and the 30 kpph is used to pick up peak demand. There are several alternatives to convert the three boilers: one, two, or three in combinations of 70 and 70 or 70 and 30. Another alternative included a new boiler to tie into the existing steam system to use exhaust steam from an electrical generating facility.

Two of several economically feasible alternatives were studied in detail. 1) Convert one of the 70 kpph boilers to use wood. 2) Build a cogeneration plant adjacent to the existing heating plant. The cogeneration plant would be capable of providing 89 percent of the steam required by and could produce 1200 kilowatts (KW) of electricity.

The second alternative is better. A benefit not apparent in the analyses is that the UM would keep its existing heating system. Any problem with the new system could be solved using the existing system as backup.

THE PROPOSED SYSTEM

The requirements of the cogenerating system for wood are estimated to be 20,041 units of biomass per year. (A unit is 200 cubic feet (FT^3) of chipped wood with an energy content of 16.5 million British thermal units at 50 percent moisture.)

Using the system for heating and selling the cogenerated electricity to UM or the Montana Power Company (MPC) could result in gross savings of $1,242,778 per year. Depending on wood cost, the net savings could range from a quarter- to three-quarters of a million dollars per year.

The full details of the analyses and the basis for selecting the cogeneration alternative as the most desirable one can be found in Appendix B.

BIOMASS SUPPLY

LEF has 300,000 units of biomass in second-growth stands, a 15-year supply. It is estimated that on much of the land in LEF the annual growth rate for biomass is 0.5 units per acre per year when those acres are intensively managed.

Missoula County has 150,000 acres of private non-industrial forest acres and 79,000 acres of state land. The total growing stock on those lands is estimated to be 370 million ft^3 of solid wood. Seventy-five ft^3 of solid wood equals one 200 ft^3 unit of chip biomass. Therefore, the growing stock is equivalent to 5 million units of biomass. Approximately one-half of that could be available from thinnings and improvement cuttings based on the experiments conducted in LEF. Many second-growth stands need thinning and improvement cuts. A market for biomass from such operations would be a boon to forest management as well as to the area economy.

LEF is an experimental forest with a multipurpose assignment. While the entire requirement could be met from LEF for two or more decades, that seems an unwise course. It may also violate the spirit with which LEF was donated to UM and there could be legal constraints.

The proposed alternative is for LEF to supply 5,000 of the 20,041 units required annually. The remaining 15,041 units would be obtained by LEF and delivered to the UM with LEF acting as the broker. The 5,000 units would be an intra-university transfer and the remainder a quasi-commercial venture. Based on the apparent supply on private non-industrial and state forest land in Missoula County, there is an ample wood for this and many similar operations. Wood from federal and industrial lands was excluded from the supply base.

Economic theory says that a large supply lowers cost. In this case the supply is more than adequate. Whether the biomass units can be delivered to the University will depend largely on price. Based on 1984 costs for labor, equipment and supplies, and on LEF's operating costs that have been experienced in recent years, it is estimated that the units can be delivered for $47 per unit. This is a high estimate. Large scale thinning and cutting could bring the price down, but it is impossible to estimate how far. The above estimates include: marking, cutting, skidding, chipping, hauling, roading, stumpage, supervision, brokering and ash redistribution. See Appendix C for the full report.

The gross savings of $1,242,778 would be reduced to a net of $300,851 after paying $921,927 for the wood. The wood cost would benefit the local economy with its multipliers. It is expected to contribute to Missoula economy substantially more than UM's annual million dollar purchase of natural gas.

The technical, managerial, and institutional issues that need to be resolved are several: 1) Can LEF operate as the broker? 2) How do the State of Montana, Board of Regents, UM, and LEF use this opportunity? 3) How could UM and LEF benefit from lower heating and lighting costs? Could the savings be shared between the state general fund and LEF? 4) How much will be paid for cogenerated electricity. That price is being debated by the Public Service Commission (PSC) and MPC and is an important factor in the economic feasibility of cogenerated power.

GRANT ADMINISTRATION

This project moved with speed despite a tight budget. DNRC personnel tended to expect more than was bargained for, particularly from the subcontracted engineers. The subcontractor's problem was that companies that could give Code A cost estimates usually charge more than the total grant amount to provide that information.

Reassignment of duties in the School of Forestry and the Montana Forest and Conservation Experiment Station made it possible to complete the project.

Budget

	DNRC	UM
Milestone 1		
Salaries and Benefits	$ 2,100	$ 880
Indirect Costs	420	475*
Milestone 2		
Salaries and Fringe	2,000	1,600
Contracted Services	8,000	
Indirect	2,000	864
Milestone 3		
Salaries and Fringe	6,480	4,000
Indirect	1,360	2,160
Travel		263
Computer Use and Plotting of Maps		2,400
Milestone 4		
Salaries and Fringe	660	8,700
Indirect	440	4,670
Travel	1,500	504
TOTALS	$24,960	$26,516
PROJECT TOTAL		$51,476

CONCLUSIONS AND RECOMMENDATIONS

1. It is legally, environmentally, and biologically feasible to provide up to 89 percent of UM's heat requirement using biomass and to produce simultaneously cogenerated electricity.

2. Wood supply is ample to meet the projected requirements on a continuing basis. Part of the supply would come from LEF and part from private non-industrial and state forest land.

3. The initial investment in an emission free cogenerating plant is estimated at $4,412,600. Such a plant could save $300,000 per year in heating and lighting costs at UM. It is beyond the scope of this project to evaluate such an investment.

4. It is recommended that UM, the Board of Regents and appropriate Executive and Legislative Offices be informed of this opportunity when DNRC accepts this report.

APPENDIX A

MILESTONE 1

LEGAL RAMIFICATIONS OF USING BIOMASS FOR HEAT AND CO-GENERATED ELECTRICITY AT THE UNIVERSITY OF MONTANA

Intra-campus MEMORANDUM

APPENDIX A

UNIVERSITY OF MONTANA
SCHOOL OF FORESTRY

DATE: July 23, 1984

TO: Montana DNRC, Attention: H. Haines

FROM: B.B. Stout, Dean, School of Forestry

SUBJECT: Biomass Utilization Project, ED-BS-733, Milestone I Report

An investigation of the legal ramifications of using biomass for heat and co-generated electricity at the University of Montana (UM) has been conducted. Two copies of the report of the investigation by Maurice M. Michel are attached as Exhibit B.

The report notes that Missoula is a noncompliance area for CO at certain times of the year. The omission of CO by a boiler fired with biomass depends on many factors: wood moisture content and availability of O_2 in the firebox. Reports on CO emissions vary. Entropy Environmentalists, Inc., P.O. Box 12291, Research Triangle Park, NC 27709, report on a 17,250 lb. boiler that 0.0 CO is emitted. Other reports show up to 47 lb. of CO per ton of fuel. Based on the NC report, dated December 1980, we conclude that it is technologically feasible to use biomass to heat/generate at UM without adding CO to the atmosphere.

A report by D.C. Junge, Forest Research Lab, Oregon State University, Corvallis, OR 97331, dated November 1975, indicates that the technology is available to remove particulates from the flue gases.

On the basis of these reports we conclude that biomass can be used at UM without contributing to particulate concentrations.

The UM has three boilers. The report by J.A. Parker and his staff is attached as Exhibit A.

We request permission to proceed to Milestone 2, Heating Plant Modifications.

plm

cc: Dr. Murray
Mr. Parker
Mr. Drapes

Enclosures

Intra-campus MEMORANDUM

Exhibit E

UNIVERSITY OF MONTANA

DATE: April 27, 1984

TO: Dean Benjamin B. Stout, School of Forestry

FROM: Maurice M. Michel, School of Law Maurice Michel

SUBJECT: Biomass Utilization Project - Montana Department of Natural Resources Grant

Attached is a report of the legal investigation of the proposed utilization of biomass to generate heat and electricity for the University of Montana.

In my opinion it would not be possible to carry out this project and be in compliance with current laws and regulations governing air pollution in the City of Missoula.

cc: Dr. Raymond Murray, Vice President for Research

MISSOULA CITY-COUNTY
HEALTH DEPARTMENT
301 West Alder · Missoula, Montana 59802 · Ph. (406) 721-5700

August 10, 1984

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SCHOOL of FORESTRY
UNIVERSITY of MONTANA

Dean Stout
School of Forestry
University of Montana
Missoula, MT 59812

Dear Dean Stout:

After several months of calling and writing, I have finally gotten an answer concerning the emissions resulting from the conversion of the University heating system. I am enclosing a copy of the letter.

Please note that this is much less restrictive than that which is indicated in the Law School's legal review. Please call if you have any questions.

Sincerely yours,

James H. Carlson
Air Pollution Control Specialist

JHC:mzc
Enclosure

United States
Environmental Protection
Agency

Region 8, Montana Office
Federal Building
301 S. Park, Drawer 10096
Helena, Montana 59626

10b

AUG 0 6 1984

Ref: 8MO

Mr. J. H. Carlson
Air Pollution Control Specialist
Missoula City-County Health Department
301 West Alder
Missoula, Montana 59802

Dear Jim:

In response to your July 19, 1984 letter concerning a possible conversion of the University of Montana boiler plant from natural gas to biomass (wood) combustion in a nonattainment area, I am writing to outline applicable Federal requirements.

If the boiler plant is currently a "major stationary source" undergoing a "major modification" or would become a "major stationary source" as a result of conversion it may be required that the "lowest achievable emission rate" (LAER) be met and emission offsets be implemented as specified in 40 CFR 51, Appendix S - Emission Offset Interpretative Ruling. A major stationary source is one which has the potential to emit more than 100 tons per year (tpy) of any regulated pollutant (CO, NO_x, SO_2, particulate matter, volatile organic matter (VOC), or Pb). A major modification is a modification resulting in a significant net emissions increase; a significant increase is 100 tpy CO, 40 tpy NO_x, 40 tpy SO_2, 25 tpy particulate matter, 40 tpy VOC or 0.6 tpy Pb.

In order for the proposed conversion to avoid requirements for LAER and emission offsets in Missoula it should remain a non-major source for CO and particulate matter. Should the source become major for CO or particulate matter, LAER and emission offsets may be required in the event of an allowable increase in emissions of 50 tons per year, 1,000 pounds per day or 100 pounds per hour.

The plant is probably major for NO_x at this time, but conversion would not likely increase NO_x emissions. Uncontrolled potential emissions of CO and particulate matter from a plant this size would probably make it a major stationary source; emission controls required in a permit from the State or Missoula might, however, reduce emissions such that the plant would not be major for CO or particulate matter.

We would appreciate an opportunity to review such a permit prior to issuance though we expect the product of the State and Missoula permit review process will require no formal EPA approval regarding the Missoula attainment planning process.

Should you have further questions, please call me at 449-5486.

Sincerely,

Jay Sinnott
Environmental Engineer

cc: Hal Robbins, AQB

MEMORANDUM

The federal Clean Air Act and accompanying regulations establish minimum state air quality standards, but the states retain primary responsibility for the prevention and control of air pollution. 42 U.S.C. 7401. The Montana Clean Air Act, enacted prior to the major federal revisions of 1977, has since been amended to reflect the federal requirements. See 75-2-101 - 429 MCA.

The federal Environmental Protection Agency, through the Administrator, retains jurisdiction to order compliance with a state plan or with federal new source requirements and, in addition, to bring civil action for injunction and penalties. 42 U.S.C. 7413(a)(1), (3). The Act provides for civil penalties of up to $25,000 per day of violation, 42 U.S.C. 7413(b). Where violation continues after order or where the violation involves a new source, criminal penalties of up to $25,000 per day plus one year imprisonment may be imposed.

Along with federal law and,depending upon the size and emission potential of the proposed facility, either state or local regulation will govern initial application and permitted operation. Like or similar regulations govern in either instance; both provide for civil penalties of $10,000 and criminal penalties of $1,000 per day of violation. 75-2-412, 413 MCA; Missoula City-County Air Pollution Control Program (APCP) sections XV, XVI. If the facility is designated a "major stationary source," state regulation will apply. See 75-2-301(6) MCA (authorizing local pollution control programs but retaining state control of air contaminant sources where complexity or magnitude is beyond the capacity of the local jurisdiction to regulate).

MAJOR STATIONARY SOURCES

The federal Clean Air Act both compels compliance with the minimum federal primary and secondary air quality standards and mandates state implementation of plans for control of air pollution. 42 U.S.C. 7409, 7410. Montana's implementation plan, comprising several volumes, has been approved by the Environmental Protection Agency with the exceptions, including that for Missoula, set forth in 40 C.F.R. 52.1372.

The plan provided that Missoula would meet primary and secondary standards for particulate matter by December 31, 1982. When the plan was adopted, carbon monoxide levels for the Missoula area met secondary standards. 40 C.F.R. 52.1375. Missoula is now, however, designated a nonattainment area for both total suspended particulate and carbon monoxide. 40 C.F.R. 81.327.

> No major stationary source shall be constructed or modified in any nonattainment area . . . if the emissions from such facility will cause or contribute to concentrations of any pollutant for which a national ambient air quality standard is exceeded in such area, unless, as of the time of application for a permit for such construction or modification, [the state's] plan meets the requirements of part D of this subchapter.

42 U.S.C. 7410(a)(2)(I) (emphasis added).

The Code's definition of "modification" would include the University's proposed boiler conversion. 42 U.S.C. 7411(a)(4) ("any physical change in . . . a stationary source which increases the amount of air pollutant emitted by such source or which results in the emission of any air pollutant not previously emitted").

Part D requires, as a precondition for the construction or modification of any major stationary source, that state implementation plans related to nonattainment areas provide for attainment of primary air quality standards no later than December 31, 1982. 42 U.S.C. 7502(a)(1). Where, as here, a state has failed to meet the required standards, the EPA Administrator may issue an order prohibiting construction or modification of any major source. 42 U.S.C. 7413(a)(5). An order was issued, November 2, 1983, banning any major stationary source that would cause or contribute to carbon monoxide concentrations in the Missoula area. 48 Fed. Reg. 50686. See also 48 Fed. Reg. 5005, App. D.

In Montana, a "major" stationary source is defined as (1) certain enumerated facilities (not including wood fueled boilers) with the potential to emit 100 tons per year or more of any pollutant subject to regulation under the Act or (2) any stationary source which emits, or has the potential to emit, 250 tons per year or more of any pollutant subject to regulation under the Act. A.R.M. 16.8.921(22). "Potential to emit" has been held to mean not uncontrolled emissions, as contended by the EPA, but the anticipated emissions with all air pollution control equipment in place. Alabama Power Co. v. Costle, 636 F.2d 323, 353 (D.C. Cir. 1980). This interpretation has been incorporated in the federal and Montana regulations. 40 C.F.R. 51.18(j)(1)(iii); A.R.M. 16.8.921(27).

The 250 tons per year of carbon monoxide standard would apply, here, to determine "major" under state regulations. (The emissions for each pollutant are considered separately so that the proposed source could emit 249 tons of carbon monoxide and 249 tons of particulate without being classified as "major".)

A question remains, however, on the longevity and validity of Montana's "major source" definition and the 250 ton standard. A like federal definition appears at 42 U.S.C. 7479(1) but applies only to part C of the Act, "Prevention of significant deteriorization of air quality." Part C is addressed only to the protection of air quality once national standards have been attained. See 42 U.S.C. 7470(1). The general federal definition of "major stationary source" is any "facility . . . which directly emits, or has the potential to emit, 100 tons per year or more of any pollutant". 42 U.S.C. 7602(j). The definition applies to all but part C of the Act. The section 7602 definition is used throughout the federal regulations where nonattainment areas are involved. See e.g. 40 C.F.R. 51.18(l)(iv)(a). Compare 40 C.F.R. 51.24(b)(1)(i) where major source is defined for purposes of part C.

The 100 ton standard should be used in this instance; the 7602(j) definition clearly applies to part D nonattainment areas and a source emitting 100 tons of any pollutant would be classified as major for federal purposes. [42 U.S.C. 7413(b)(5) provides that the Administrator shall seek an injunction or assess civil penalties of not more than $25,000 per day of violation, or both, whenever a "person" attempts to construct or modify a major stationary source in any nonattainment area. "Person" is not specifically defined under federal law to include a state agency. Only the broad term "state" appears in the definition (42 U.S.C. 7602(e)), but simple agency theory would hold the state liable for the acts of any agency or instrumentality.] A 100 ton source of carbon monoxide would be banned completely under the present order. A 100 ton source of particulate, although not banned under the 1983 order, could potentially be enjoined or penalized under sections 7413(a) and (b).

In the event that Missoula makes "reasonable further progress" toward attainment of air quality standards (defined as "annual incremental reductions in emissions . . ., including substantial reduction in the early years following approval of plan provisions", 42 U.S.C. 7501(1)) and the outright ban is lifted, or if the facility is a major source of particulate only, part D of the federal act and the corresponding federal and state regulations require that the proposed source demonstrate that

> by the time the source is to commence operations, total allowable emissions from existing sources in the region, from new or modified sources which are not major emitting facilities, and from the proposed source will be sufficiently less than total emissions from existing sources allowed under the applicable implementation plan prior to the application for such permit to construct or modify so as to represent . . . reasonable further progress.

42 U.S.C. 7503(1)(A).

Put in simpler terms, the new source would have to prove that emissions from all other sources would be reduced by a greater amount than the amounts of emissions to be added by the new source.

Where, as here, the proposed new source is within a nonattainment area for particulate, the source must apply the lowest achievable emission rate (LAER). 42 U.S.C. 7503(2); A.R.M. 16.8.1401(5)(c). (The requirement applies to any source with the potential to emit more than 100 tons of particulate per year, whether or not the source is otherwise qualified as "major".) [Montana's EPA has not promulgated a similar regulation for carbon monoxide but, instead, incorporates federal requirements in the conditions listed for issuance of permit. A.R.M. 16.8.1109(2). See 42 U.S.C. 7503(2) (requiring that all new or modified major sources in a nonattainment area comply with the lowest achievable emission rate).]

"Lowest achievable emission rate" is defined as a rate of emissions which reflects, "the most stringent emission limitation which is achieved in practice by such class or category of source". 42 U.S.C. 7501(3)(B); A.R.M. 16.8.1101(6)(b). This "state of the art" standard is more readily and more affordably achievable with particulate than with carbon monoxide. [For technical assistance and advice, call Hal Robbins, Air Quality Bureau, Helena - 444-3454.]

In summary, a major source of carbon monoxide emission may not be constructed, either as a new facility or as a modification of an existing facility. A major source of particulate, although apparently permitted by state law, is expressly prohibited under part D of the federal act and under the federal act could be subject to injunction and penalty. See 42 U.S.C. 7410(a)(2)(I) (prohibiting any state plan provision allowing construction or modification of a major source in any nonattainment area if the emission from the facility will cause or contribute to concentrations of a pollutant for which the national air quality standard is exceeded); 42 U.S.C. 7502(a)(1) (requiring compliance with national primary standards as a precondition for the construction or modification of a major source); 42 U.S.C. 7413(a)(5) (requiring that the Administrator bring action for injunction or penalty or both against an owner attempting to construct or modify a source in violation of either 7502(a)(1) or 7413(a)(5)).

"Major" should be measured on the 100 ton federal standard and, under Alabama Power and subsequent regulations, on an after-control equipment basis.

NEW, NONMAJOR SOURCE

State regulations prohibit issuance of a permit for any new or altered source in a nonattainment area if the applicable implementation plan is not being carried out. A.R.M. 16.8.1109(7). ("New or altered source" is defined as one upon which construction has not commenced prior to March 16, 1979. A.R.M. 16.8.1101(1).) Missoula has failed to carry out its proposed plan for compliance with national particulate and carbon monoxide standards or to implement a plan that will achieve compliance with national standards for carbon monoxide. 40 C.F.R. 81.327; 48 Fed. Reg. 50686. The Missoula regulations do not contain a similar prohibition and, as noted above, local regulation will govern construction or modification of a nonmajor source. The conflict between state and local regulation has not, as yet, been challenged, and the more lenient local standard is not specifically prohibited under the statutory grant of local jurisdiction. See 75-2-301(a) MCA (requiring only that local regulations be compatible with the state's regulation of emission levels, variances, and emergency procedures). The grant of jurisdiction also, however, provides that, where a local program proves inadequate and, after hearing and attempted correction, remains inadequate, the department shall administer the state's control program. 75-2-301(3) - 301(5) MCA.

Assuming either that Missoula develops an effective implementation plan or that, notwithstanding the A.R.M. 16.8.1109(7) prohibition, a new nonmajor source is allowed, the application requirements and procedures of APCP section XI apply. (Again, the proposed modification brings the facility within the definition of new source. 42 U.S.C. 7411(a)(2), (4); APCP section X, 1410(21)(b).)

> Section XI, 1102(a) A permit is required for all institutional solid fuel burning equipment of greater than 5,000,000 Btu per hour heat input (accord A.R.M. 16.8.1102(a)).
>
> Section XI, 1103 A source for which a permit is required shall utilize the "best available control technology".

"Best available control technology" means an emission limitation, based on the maximum degree of reduction for each pollutant which would be emitted from the proposed source which the Department, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source through application of production processes or available methods, systems, and techniques, but in no event shall application of best available control technology result in emissions which exceed the allowable standards under A.R.M. 16.8.1423, -1424.

A.R.M. 16.8.1424 applies to hazardous air pollutants — asbestos, beryllium, mercury, and vinyl chloride. (40 C.F.R., part 61);

A.R.M. 16.8.1423 incorporates the federal new source standards of title 40, part 60 of Code of Federal Regulations. Part 60 sets out the applicable standards of performance for new stationary sources and applies only to the sources for which standards have been promulgated. A wood-fired steam generator is not among the enumerated facilities and so, arguably, not subject to federal and, thus, not state regulation of new source performance standards. Subpart D of Part 60 creates performance standards for fossil-fuel-fired steam generators. Included within the affected facilities are fossil-fuel and wood-residue-fired generating units capable of firing fossil fuel at a heat input rate of more than 73 megawatts (250 million Btu per hour). 40 C.F.R. 60.40(a)(2). Wood residue is defined as "bark, sawdust, slabs, chips, shavings, mill trim, and other wood products derived from wood processing and forest management operations". 42 C.F.R. 60.41(e). ("Other products . . . of forest management operations" would include firewood taken from a thinning operation.)

The subpart, as noted, does not specifically apply to an all wood-fired operation and does not provide a standard for carbon monoxide emissions. The standard for particulate emissions prohibits discharge of any gases containing particulate matter in excess of 43 nanograms per joule heat input (0.10 lb. per milltion Btu) or exhibiting greater than 20 percent opacity (except for one six-minute period per hour of not more than 27 percent opacity). 42 U.S.C. 60.42(a). The standard should be viewed merely as a nonmandatory guideline. Nothing in the federal code suggests that the new source standards are to be applied to any but the particularly described facilities. (The code directs the Administrator to publish a list of categories of sources and performance standards for included sources where, in his judgment, the category causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare. 42 U.S.C. 7411(1)(A), (B).)

Given the absence of a specific standard, the "best available control technology" will be determined by the Department on a case-by-case basis. (Department of Health and Environmental Services, Cogwell Building, Helena, Montana 59601.)

> Section XI, 1105 Prior to construction or modification, an application must be submitted to the Missoula City-County Health Department, on a form provided by the department. The application must include:
>
> (a) A map and diagram showing the location of the proposed new or altered source and each stack associated with the source, the property involved, the height and outline of the buildings associated with the source, and the height and outline of each stack associated with the source;
>
> (b) A description of the new or altered source including data on expected production capacity, raw materials and major equipment components;
>
> (c) A description of the control equipment to be installed;
>
> (d) A description of the composition, volume and temperature of the effluent stream, including the nature and extent of air contaminants emitted, quantities and means of disposal of collected contaminants, and the air quality relationship of these factors to conditions created by existing sources or stacks associated with the source.
>
> (e) Normal and maximum operating schedules;
>
> (f) Adequate drawings, blueprints, specifications or other information to show the design and operation of the equipment involved;
>
> (g) Process flow diagrams containing material balances;
>
> (h) A detailed schedule of construction or alteration;
>
> (i) A description of the shakedown procedures and time frames that will be used; and
>
> (k) Such other information as requested by the Department.

The City-County regulations include a provision allowing the Department to waive the requirement that any of the above information accompany an application, but waiver would, with a large facility, be unlikely. (Again, the local regulations appear to be impermissibly less stringent than state regulation. The corresponding state permit requirements may not be waived. A.R.M. 16.8.1105; 75-2-211(5) ("The Department shall require that applications for permits be accompanied by plans, specifications . . . .")

> Section XI, 1107 The permit application of a new source with the potential to emit more than 25 tons per year of any pollutant is subject to public hearing and review.

Section XI, 1109 conditions permit issuance on compliance with the provisions of the APCP. Except where specifically provided by the APCP, the permittee must also comply with all applicable federal or state regulations. (APCP section XI, 1117)

As noted above, state regulation 16.8.1109(7) would prohibit issuance of permit for any new or modified source of carbon monoxide. (Solid fuel equipment of less than 5,000,000 Btu per hour input is exempted from permit requirements.) The local rules both incorporate state regulations and except a source from compliance thereunder by specifically providing application requirements and procedures for a source otherwise prohibited under state law until Missoula has implemented a successful plan for compliance with the air quality standards for carbon monoxide.

Missoula has established standards for maximum allowable particulate emissions from fuel burning equipment. (_See_ attached chart.) Levels of allowable emissions are determined on the basis of the equipment's per hour heat input. Heat input is calculated as the aggregate heat content of all fuels (using the upper limit of their range of heating value) whose products of combustion pass through the stack; when two or more fuel burning units are connected to a single stack, the combined heat input of all units connected to the stack is to be used to determine the allowable emission from the stack. APCP section X, 1450(2).

New equipment in the 100 to 1,000 million Btu per hour range has a maximum allowable emission rate of .2 pounds per million Btu; equipment with heat input of 1,000 million Btu per hour and above has a maximum allowable rate of .12 pounds per million Btu. The obvious inadequacy of the local standards (and indentical state standards) becomes apparent when the permitted hourly emission rate is totalled for potential hours in use. Wood-burning equipment emitting at the upper rates will be deemed a major facility for federal purposes and so become subject to the stricter requirements of part D of the Act. The reduced total emissions and "state of the art" control equipment requirements of part D are discussed under Major Stationary Sources, above. As also noted, A.R.M. 16.8.1401(5) requires that a new source with the potential to emit more than 100 tons per year of particulate apply the lowest achievable emission rate. Once Missoula has attained and maintained national air quality standards, the provisions of part C of the Act and the accompanying regulations will apply. See 42 U.S.C. 7470-7491; 40 C.F.R. 51.24.

APCP section X, 1460 prohibits the emission of visible air contaminants "(a) of a shade or density darker than that designated as No. 1 on the Ringelmann Chart, or (b) of such opacity as to obscure an observer's view to a degree greater than does smoke described in (a)." Exceptions are provided, however, when a denser opacity (of less than No. 3 on the Ringelmann) is caused by the building of a new fire, cleaning of fires or soot blowing or where the presence of uncombined water is the only reason for failure to meet the requirements. APCP section X, 1460.

No state or local carbon monoxide source emissions standards have been promulgated. The state has, of necessity and with slight modification, adopted the federal primary and secondary ambient air quality standard:

> No person shall cause or contribute to concentrations of carbon monoxide in the ambient air which exceed any of the following standards:
>
> (a) Hourly average: 23 parts per million, hourly average, not to be exceeded more than once per year.
>
> (b) Eight-hour average: 9 parts per million, eight-hour average not to be exceeded more than once per year.

A.R.M. 16.8.811(1). Compare 40 C.F.R. 50.8 (permitting 35 parts per million as a maximum one-hour concentration).

As previously noted, the only state regulation to address new source requirements incorporates the particular source provision of title 40, part 60, C.F.R. Since those provisions are not here specifically applicable, only the very general prohibitions of the "cause or contribute" language of A.R.M. 16.8.811 offer any guidance or provide any restriction. Given the technological difficulties involved in controlling carbon monoxide emissions and the potential for assessment of federal penalties as well as private damages, the State Air Quality Bureau (Hal Robbins) and Department of Health and Environmental Sciences should be consulted for estimated safe emission levels and suggested control equipment.

PRIVATE DAMAGE ACTIONS

Federal and state penalties are provided where a new or modified source causes or contributes to emissions that exceed air quality standards. 42 U.S.C. 7413(b)(3), 7412(c)(1)(A); 75-2-413(1) MCA. Both acts, however, also specifically retain the "right of a person to damages or other relief on account of injury to persons or property and to maintain an action or other appropriate proceeding". 75-2-104(4) MCA; 42 U.S.C. 7604(e) ("Nothing in this section shall restrict any right which any person may have under any statute or common law . . . to seek any other relief (including relief against the Administrator or a State agency)").

A private cause of action for trespass or nuisance will lie where an invading emission is involved. See French v. Ralph E. Moore, Inc., 661 P.2d 844 (Mont. 1983) (upholding a $190,000 award for pain and suffering caused by gas fumes). Punitive damages may also be assessed where "defendant has been guilty of oppression, fraud, or malice, actual or presumed". 27-1-221 MCA. (Inaction after clear knowledge of the invasion appears to be the single greatest factor in finding the malice required for punitives. See Atlas Chemical Industries, Inc. v. Anderson, 524 S.W.2d 681 (Tex. 1975) (punitives awarded where defendant continued to discharge lignite sediment in violation of state water quality standards). Compare Ferguson v. Town Pump, Inc., 580 P.2d 915 (Mont.

1978) (punitives denied where the Department of Health received defendant's "full cooperation" after notice of contamination).)

A trespass action requires a showing only of actual trespass without requirement of proof of injury. Nominal injury is assumed, and, from a finding of such nominal injury, punitives may be awarded. Where a public, as opposed to private, nuisance is, as would be here, involved, the plaintiffs must show that defendant has caused them an injury greater than that suffered by the general population. (The requirement of special injury is an element of "standing" for a public nuisance action and a necessary prerequisite to the bringing of suit.) Neither the federal nor state acts expand the traditional notions of standing; plaintiffs must still show that a public nuisance is "especially injurious" as to them. Desmond v. General Motors Corp., 97 Cal. Rptr. 639 (1971) (analyzing standing under the water quality act).

A class action on behalf of all Missoula residents would be barred, by the "clean hands" doctrine, from a claim for injunctive relief. (He who is seeking relief from a court of equity must himself be without fault.) No similar doctrine would, however, apply to an action for damages; rather the doctrine of comparative negligence would be relied on to distribute fault. In addition, any injured individual or a class of noncontributing residents would potentially have standing to seek both injunction and damages.

Any nuisance action would require proof that defendant's actions caused plaintiffs' injuries. The causal link is difficult to prove directly, but the federal and state acts set up the presumption of cause: the purposes of both acts include the protection of public health, 42 U.S.C. 7401(b)(1), 75-2-102(1) MCA; the implementing agencies are directed to identify air contaminants which "may reasonably be anticipated to endanger public health", 42 U.S.C. 7408(a)(1)(A), 75-2-201(1) MCA; the national primary ambient air quality standards are those which, in the judgment of the Administrator, are necessary to protect the public health, 42 U.S.C. 7409(b)(1).

Designation of an air pollutant for the purpose of establishing primary air quality standards requires proof of demonstrable harm caused by the pollutant. 42 U.S.C. 7409(d); Ethyl Corp. v. Environmental

Protection Agency, 541 F.2d 1 (D.C. Cir. 1976) cert. den. 426 U.S. 941; accord U.S. v. Atlantic-Richfield Co., 478 F.Supp. 1215 (D. Mont. 1979) (elaborating on the primary (health) and secondary (welfare) criteria in a trespass action involving emissions).

Promulgation of a national primary standard for any pollutant sets up a presumption of both cause and injury to the exposed plaintiff. See 40 C.F.R. 50.6 (primary ambient air quality standards for particulate matter); 40 C.F.R. 50.8 (national ambient air quality standards for carbon monoxide); 42 U.S.C. 7409(b)(1). The Montana Act arguably limits plaintiff's reliance on its provisions to create or enlarge a right of action (See 75-2-104(4)), but the relevant federal provision makes no similar restriction on use of the act. 42 U.S.C. 7604(e). Any action would almost certainly be brought in a federal court of competent, and impartial, jurisdiction.

[Note, however, that the Montana Constitution guarantees to every person the fundamental right to a clean and healthful environment. MONT. CONST. ART. II, section 3. The right is separate and independent of any right protected under the Clean Air Act, and the Act and regulating agencies are subject to the constitutional mandate.]

The named defendant in any action need not be the sole cause of injury. Liability under federal provisions arises upon violation of any plan, requirement, or order. 42 U.S.C. 7413. The Montana regulations of particulate and carbon monoxide specifically prohibit emissions that cause or contribute to concentrations in excess of primary air quality standards. A.R.M. 16.8.811, 821.

CONCLUSION

A "major" source — defined as one emitting 100 tons or more per year of any regulated pollutant — may not be constructed or modified until Missoula has achieved national ambient air quality standards. A new or altered nonmajor source of carbon monoxide capable of 5,000,000 Btu per hour heat input, while not expressly prohibited under local regulation, is prohibited by state regulation until Missoula either implements an attainment plan with which it can comply or complies with the terms of the present plan. If a nonmajor source is permitted, either as a result of plan compliance or through local failure to adhere to state regulation, determination of the appropriate emissions control equipment will — or should — be made by the state's Department of Health and Environmental Sciences.

Even though permitted by state or local regulating agency, the facility — as a large and highly visible deep pocket polluter — would almost certainly be subjected (along with the regulating agency) to private damage action or suit for injunction.

Maurice M Michel

April 27, 1984

APPENDIX B

BIOMASS UTILIZATION PROJECT

MILESTONE 2

PREPARED FOR
UNIVERSITY OF MONTANA
MISSOULA, MONTANA
DECEMBER 5, 1984
REVISED FEBRUARY 6, 1985

BY
DRAPES ENGINEERING
312 1ST AVENUE NORTH, SUITE 202
GREAT FALLS, MONTANA
DE84-303-02

PHYSICAL PLANT CHANGES FOR BIOMASS FUEL USE

CURRENT HEATING SYSTEM

UM has three boilers in the central heating plant. Boilers #1 and #3 are Keeler Model MKB boilers each rated at 70,000 pounds of steam per hour. Boiler #2 is a Babcock and Wilcox package boiler (see Exhibit A) rated at 30,000 lbs per hour.

Although the central heating plant has been fueled by coal and wood in the past, all of the auxiliary equipment such as ash and wood conveyors have been removed and the fuel-storage building has been remodeled for other use. The existing boilers, installed in the 1960's, all use natural gas for fuel. Boilers #2 and #3 can also burn #2 fuel oil. The boilers have maximum pressure ratings of 200 to 250 lbs per square inch, too low for electrical generation. The boilers operate at 110 psi to satisfy demand to the physical plant. The main campus is supplied steam at 40 psi.

ALTERNATIVES TO THE CURRENT SYSTEM

One alternative analyzed in the report is converting of one of the Keeler boilers to burn wood. According to the factory, these boilers have been used to burn wood and conversion is feasible although required modifications would be extensive.

The other alternative is a new high-pressure boiler located next to the heating plant that would produce steam and electricity.

The 1983 heating plant log-sheets provided three hour and daily steam readings that were used for the analysis. A weighted multiplier was used for the three hour readings to match the daily totals. Exhibit D shows the data summary.

The total steam produced in 1983 was 203,494,000 lbs which agrees with the 1982-83 use of 198,169,000 lbs and the 1983-84 use of 207,761,000 lbs.

Degree days for 1983 were 7,655, just under the long-term average of 7,931 degree days. The natural gas use for 1983 was as follows:

Boiler #1	207,396
Boiler #2	30,838
Boiler #3	8,401
	246,635

Typical operation is to fire Boiler #2 during the summer with Boilers #1 and #3 shut off. Boiler #2 is shut off in the fall and Boiler #1 is fired until spring. Boiler #3 is brought on line on a low-fire, standby basis during periods of heavy load.

The wood is assumed to be chipped (hog fuel) with a heating value of 5,500 Btu/lb or 16.5 million Btu's per unit with a 50 percent moisture content. Wood requirements and steam yield are calculated in Exhibits B and C.

MODIFICATION OF AN EXISTING KEELER BOILER

Boiler Modifications

The boiler would be modified to accept a wood-burning stoker. This would include raising the boiler one to two feet, cutting out the furnace floor tubes, and providing a new front-wall header with circulating tubes. Other boiler modifications and pressure part changes would be necessary for stoker firing. The existing gas burners and associated piping would have to be relocated. See Figures 2, 3, 4, 5, and 7 for drawings of existing and proposed equipment.

Water-Cooled Stoker

A water-cooled stoker was selected to handle high-moisture fuels and auxiliary oil or gas without damaging the grate. The spreader-stoker package includes a 14-ft 6-in-wide by 11-ft-long vibrating grate, three 30 in air-swept spouts and complete overfire air and fly-ash reinjection system.

Air Preheater

The existing flue-gas economizer was not designed for woodburning. It would be replaced with a tubular air preheater that would reduce furnace exit gas temperatures to 350^{0} (degrees F.), and supply 450^{0} F under grate air.

Induced-Draft Fan

The existing 40 horsepower (hp) induced-draft fan would be replaced with a 150 hp fan to handle the high static of the new system (approximately 20 in of static pressure). The air scrubber causes high static pressure.

Multiclone Dust Collector

This would be inserted between the boiler and the scrubber to remove most of the particulate from exit gases. See Figure 6.

Wet Scrubber

This appears to be the most effective device currently in use for removal of the smaller particles that come through the multiclone. Advantages of the wet scrubber versus a baghouse include smaller space requirements, lower maintenance requirements and elimination of fire danger. Disadvantages are messier disposal due to the slurry form of removed solids and a visible plume due to water vapor in the flue gas. This report assumes disposal will be at LEF.

Forced-Draft Fans

The existing 15 hp fan would be replaced with a 30 hp fan.

Ash Conveyor

This includes a pneumatic ash conveyor and three-day storage silo (includes explosion-relief vents and nitrogen-purge system).

Wood-Conveying System

A complete wood-handling system; including yard-feed hopper, conveying equipment, in-plant storage tank, fuel feeder, ductwork, hoods and dust-collecting equipment would be installed.

Combustion Controls

Existing controls would be modified to meet air-quality requirements, and to provide control during woodburning, and combination wood and gas burning.

Electrical Contract

This will include providing power for all the new equipment including the larger replacement fans.

Equipment Enclosure

An enclosure for the multiclone, scrubber, and ash silo, to be on the north side of the existing heating plant. See Figure 1.

The cost estimate for this conversion is $2,791,900. The estimate is itemized in Exhibit F.

Maximum output of the boiler while burning wood is lowered from 70,000 pounds per hour (pph) to 50,000 pph. Minimum boiler output would be limited to 30,000 pph to maintain sufficient heat on the grate surface to burn high-moisture-content fuel. Wood could be burned if boiler output were below 30,000 pph if it were burned along with natural gas.

The savings estimate for this conversion is based on wood supplying 50 percent of the overall load below 30,000 pph, all of the load from 30,000 to 50,000 pph, and the first 50,000 pph with loads greater than 50,000 pph. This operating range could be extended with drier fuel.

The total annual load supplied by wood would be 147,373,000 lbs which is 73 percent of the total. Using a 70 percent conversion efficiency and 16.5 million Btu per unit, the annual wood requirement would be 12,244 units. The low estimate for this wood at $25 per unit is $306,100. The high estimate at

$50 per unit is $612,200.

The natural gas savings are 178,668 mcf per year. The cost savings at $4.48 per mcf are $800,433 per year.

The increase in operation and maintenance costs is estimated to be $66,825 per year (including $18,825 for additional electricity costs).

The net savings equals $800,433 - $66,825 = $733,608.

Subtracting the cost of wood, yields an annual savings of $121,408. Simple payback would occur in 23.0 years at $50 per unit for wood.

If wood were $25 per unit, $427,508 would be saved annually and the system would pay for itself in 6.5 years.

COGENERATION WITH A NEW BOILER

The proposed cogeneration system is designed to provide up to 40,000 pph of 600 psi steam and 1,200 kW of electricity. There is a sharp price increase when the design pressure is higher than 600 pound per square inch gage (psig). It would be on the north side of the heating plant, interconnected with the existing system. This system would produce 1,054 kW when reducing 20,000 lbs of steam from 600 psig to 50 psig. There are approximately 5,000 operating hours per year with loads of 20,000 pph or more. (See 1983 boiler load summary, Exhibit D).

Using a 3.3 to 1.0 turn-down ratio, the proposed system could generate from 12,000 pph to 40,000 pph of steam on wood alone. This design makes sense because most of the operating hours occur in this range. A larger boiler with the same turndown could not supply the smaller loads while this system can supply smaller loads and most of the larger loads. The generator would also operate, albeit at reduced capacity, in the 12,000 to 20,000 pph range. Additional heat would be supplied from the existing heating plant.

The estimated cost for this alternate is $5,337,600. This is less than the cost of a complete new plant because support equipment such as water treatment and deaerators from the existing plant would be used. The itemized cost estimate is in Exhibit G.

The savings estimate for this conversion is based on wood supplying all of the load from 12,000 pph to 36,000 pph and the first 36,000 pph with loads greater than 36,000 pph. The total annual load supplied by wood under this alternate is 181,362,000 lbs which is 89 percent of the total. The annual wood requirement for heating alone is 15,071 units. The natural gas savings are 219,920 per year. The cost savings at $4.48 per mcf are $985,242 per year.

The electrical output is based on 1,000 kW output when boiler loads are 20,000 pph or greater and a reduced output when boiler outputs are between 12,000 pph and 20,000 pph. Total electrical generation is 6,487,000 kWh which would require an additional 4,970 units of wood. The electricity is considered to be sold to MPC at a 20-year levelized rate of 6-1/2 cents per kWh for an annual value of $421,655. (The buyback rates are currently under review by the PSC. Buyback rates should be considered at the time of project funding. The current buyback schedule is Exhibits E and K.)

The total annual wood requirement for this alternate is 20,041 units which would cost $1,002,050 at $50 per unit or $501,025 at $25 per unit.

The additional electrical requirements for the woodburning system are estimated to be 504,252 kWh for an annual cost of $14,119. See Exhibit J.

The increase in operation and maintenance costs is estimated to be $104,000 per year as shown in Exhibit H.

The net savings equals $985,242 + $421,655 - $14,119 - $104,000 = $1,288,778.

Subtracting the cost of wood yields an annual savings of $286,728 and a simple payback of 18.6 years at $50 per unit and a svaings of $787,753 and a simple payback of 6.8 years at $25 per unit.

Purchasing the boiler portion only (with provision for future cogeneration) would cost \$3,460,380. The annual wood requirement of 15,071 units would cost \$753,550 at \$50 per unit and \$376,775 at \$25 per unit. The increase in operation and maintenance costs for this portion is \$48,000 per year.

The net savings equals \$985,242 - \$14,119 - \$48,000 = \$923,123. Subtracting the cost of wood yields an annual savings of \$169,573 and a simple payback of 20.4 years at \$50 per unit of wood. At \$25 per unit of wood a savings of \$546,348 would occur annually paying for the system in 6.3 years.

Exhibit A

UNIVERSITY OF MONTANA
BOILERS

The present condition of the University of Montana boilers is good to excellent. All three boilers are equipped with oxygen analyzers and automatic controls. The controls are set to maintain 2% excess oxygen in the stack gases. The fire box of each boiler is surrounded with water tubes. None of the boilers have provisions for ash removal. Annual gas consumption (total) is approximately 241,000 mcf.

Boiler #	Installed	Fuel Used	Life Expectancy	Type	Make	Size
1-03347	1961	Gas Only	50 Yrs. from date of installation-with Proper Care	Model M.K.B. Water Tube	Keeler	70,000 lb/hr
2-03348	1969	Gas/Oil	Same as Above	Model F.M. Water Tube	Babcock & Wilcox	30,000 lb/hr
3-03349	1969	Gas/Oil	Same as Above	Model M.K.B. Water Tube	Keeler	70,000 lb/hr

Exhibit B

DRAPES ENGINEERING
M/E ENERGY CONSULTANTS
GREAT FALLS, MONTANA

BY SO DATE

SHEET OF

CHKD. BY DATE REVISIONS DATE

PROJECT U.M. BIOMASS TITLE ALT CASE COGENERATION

BOILER OUTPUT (1,000 POUNDS STEAM/HOUR)		STEAM LOAD CARRIED BY WOOD
2-19,020		38,280
20-35,999		97,434
> 36,000	1,268 HOURS × 36,000 =	45,648
		181,362

NATURAL GAS SAVED = 181,362 MLBS × 1.2126 = 219,920 MCF
219,920 MCF × $4.48 /MCF = $985,242

WOOD REQUIRED = 181,362 × .0831 UNITS/MLBS = 15,071 UNITS

ELECTRICAL GENERATION -
FROM SUPPLIER - R.S.M.E., INC - ASEA-STAL TURBINE
STEAM CONDITIONS:
TURBINE INLET 600 PSIG, 750°F ($h = 1380$ BTU/LB)
TURBINE OUTLET 50 PSIG 299°F ($h = 910$ BTU/LB)

UNDER THESE CONDITIONS THIS SYSTEM WILL PRODUCE 1054 KW AND 20,000 LBS OF 50 PSIG FOR EVERY 20,000 LBS OF 600 PSIG STEAM

$$\text{OVERALL EFFICIENCY} = \frac{1054\ \text{KW} \times 3413\ \text{BTU/KW}}{20{,}000\# \ (1380-910)} = 0.38$$

ELECTRICAL OUTPUT = 1,000 KW WHEN STEAM OUTPUT ≥ 20,000 #.
OF HOURS (20-36,000 #) - 3644
OF HOURS (> 36,000 #) - 1268
4912

BY S. O. DATE ______ SHEET ____ OF ____

CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______

PROJECT U. M. BIOMASS TITLE ALT CASE · COGENERATION

ELECTRICAL OUTPUT CONT.

A WEIGHTED [illegible] USED [illegible]
[illegible] R LOADS OF 12,000 TO 19,000 #S.
THE CONVERSION [illegible] %
OF THE [illegible]
EQUIVALENT FULL LOAD HOURS [illegible]

ELECTRICAL OUTPUT = 1,000 KW (4912 + 1575 HOURS) = 6,487,000 KWH

ADDITIONAL WOOD REQUIRED FOR ELECTRICAL GENERATION:

$$E = \frac{6,487,000 \text{ KWH} \times 3413 \text{ BTU/KWH}}{\boxed{.27} \times 15,500 \times 10^6 \text{ BTU/UNIT}} = 4,970 \text{ UNITS}$$

↳ OVERALL CONVERSION EFFIC = .38 (STEAM → ELEC) × .71 (WOOD → STEAM)

DRAPES ENGINEERING
M/E ENERGY CONSULTANTS
GREAT FALLS, MONTANA

Exhibit C

BY SO DATE

SHEET OF

CHKD. BY DATE REVISIONS DATE

PROJECT U M BIOMASS TITLE BOILER LOAD

BOILER LOAD READINGS ARE TAKEN AT THREE HOUR INTERVALS STARTING AT MIDNIGHT. A SUM OF THE LOAD READINGS TIMES THREE DID NOT AGREE WITH [illegible] STEAM BALANCE. THE READINGS WERE WEIGHTED TO ACCOUNT FOR MORNING WARM UP BY TAKING THE 6AM READING TIMES 1.5 AND THE 9AM READING TIMES 4.5. THE TOTAL STEAM LOAD CALCULATED BY MULTIPLYING STEAM OUTPUT BY THE WEIGHTED SUM OF HOURS AND SUMMING THE TOTAL AGREED WITH THE METERED STEAM TOTAL.

EXAMPLE: STEAM LOAD = 22,000 # (POUNDS) PER HOUR
WEIGHTED SUM OF HOURS = (18×3) + (15×3) + (10×1.5) + (4×4.5) + (5×3)
+ (6×3) + (9×3) + (14×3) = 234 HOURS

STEAM TOTAL = 22,000 #/H × 234 = 5,148,000 POUNDS OF STEAM

Exhibit D

UNIVERSITY OF MONTANA

1983 BOILER LOAD SUMMARY

BOILER OUTPUT (1000 # STM/HR)	FREQ OF THREE HOUR READINGS MIDT	3	6	9	NOON	3	6	9	WEIGHTD SUM OF HOURS	ANNUAL HOURS AT LOAD OR >	STEAM TOTAL (1000 # STM/HR)
7	1	3	1	0	1	0	1	1	23	8388	158
8	2	23	2	2	0	0	0	1	90	8310	720
9	8	40	31	0	4	1	4	3	227	8242	2039
10	10	15	28	10	7	5	9	13	268	8013	2680
11	20	5	16	8	7	14	8	20	297	7783	3267
12	34	5	12	9	13	10	11	17	329	7483	3942
13	21	7	8	15	13	15	25	27	404	7120	5245
14	14	14	4	15	20	18	11	16	323	6696	4528
15	15	6	6	17	15	20	19	11	347	6344	5198
16	11	21	9	10	6	12	20	11	308	5997	4920
17	7	12	10	7	5	14	13	15	245	5692	4157
18	15	25	10	5	6	6	7	14	263	5443	4725
19	18	17	16	3	4	15	16	8	272	5183	5139
20	26	26	27	5	14	18	16	8	387	4911	7740
21	15	16	16	5	7	10	7	9	239	4524	5009
22	18	15	10	4	5	6	9	14	234	4286	5148
23	16	10	7	4	6	13	4	20	236	4052	5417
24	11	20	16	3	7	9	7	12	236	3816	5652
25	14	13	25	13	15	13	18	11	348	3581	8700
26	14	4	13	8	12	8	8	15	239	3233	6201
27	7	7	12	6	16	12	10	12	237	2994	6399
28	10	5	11	3	12	10	4	10	183	2757	5124
29	5	3	3	9	2	7	6	11	147	2574	4263
30	8	5	11	11	11	13	12	7	234	2427	7020
31	3	3	7	17	13	8	10	7	219	2193	6789
32	2	0	4	8	11	11	9	4	153	1974	4896
33	1	0	4	7	11	7	9	11	155	1821	5099
34	2	1	2	5	6	4	8	6	107	1667	3621
35	1	4	2	9	18	7	11	2	173	1560	6038
36	3	0	2	6	10	9	5	3	120	1388	4320
37	2	2	1	7	3	5	5	5	99	1266	3663
38	1	1	1	10	7	1	7	2	104	1169	3933
39	0	1	1	7	4	5	2	3	78	1065	3042
40	0	0	1	13	4	3	5	2	102	987	4080
41	2	1	2	11	3	2	3	1	89	885	3629
42	1	0	3	7	7	2	0	1	69	797	2898

D cont.

UNIVERSITY OF MONTANA

1983 BOILER LOAD SUMMARY

BOILER OUTPUT (1000 # STM/HR)	FREQ OF THREE HOUR READINGS MID⁻	3	6	9	NOON	3	6	9	WEIGHTD SUM OF HOURS	ANNUAL HOURS AT LOAD OR >	STEAM TOTAL (1000 # STM/HR)
43	0	0	0	5	9	4	5	1	82	728	3419
44	0	0	0	4	1	4	2	0	39	646	1716
45	0	0	0	9	2	1	3	2	65	603	2903
46	0	0	2	4	5	2	1	1	45	545	2070
47	0	0	2	4	2	4	1	1	42	500	1974
48	1	2	0	4	2	2	2	1	42	458	2016
49	2	2	1	5	2	3	3	0	54	416	2646
50	2	0	1	4	3	1	1	2	47	362	2325
51	0	0	0	5	3	2	1	0	41	315	2066
52	1	3	0	2	2	0	2	0	33	275	1716
53	1	0	1	3	2	0	2	2	33	242	1928
54	1	1	1	3	0	1	0	0	24	206	1236
55	0	0	1	1	1	0	0	1	12	182	660
56	1	0	1	3	2	0	1	0	27	170	1512
57	0	0	0	1	0	1	0	0	8	143	428
58	0	1	2	2	0	0	0	0	15	135	870
59	0	0	0	3	0	0	1	1	20	120	1151
60	0	0	0	1	1	1	1	1	17	101	990
61	0	1	0	0	0	2	0	0	9	84	549
62	0	0	0	0	0	0	0	0	0	75	0
63	0	0	0	0	0	0	1	0	3	75	189
64	1	0	0	0	0	0	1	0	6	72	384
65	0	0	0	0	0	0	0	0	0	66	0
66	0	0	0	1	0	0	0	0	5	66	297
67	0	0	0	0	2	0	0	0	6	62	402
68	0	0	1	1	1	1	0	2	18	56	1224
69	2	1	0	1	1	0	0	0	17	38	1139
70	0	1	0	0	0	0	1	0	6	21	420
71	0	0	1	1	0	0	0	0	6	15	426
72	0	0	0	0	0	0	0	0	0	9	0
73	0	0	0	0	0	0	0	0	0	9	0
74	0	0	0	0	0	0	0	0	0	9	0
75	0	0	0	1	0	0	0	0	5	9	338
76	0	0	0	0	0	0	0	0	0	5	0
77	0	0	0	1	0	0	0	0	5	5	347
78	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0

TOTAL STEAM 203399

Public Service Commission of Montana

THE MONTANA POWER COMPANY
(Name of Company)

Sheet No. QFLT-84
Cancelling Sheet No. N/A
Page 4 of 5
Supp. #1

Schedule QFLT-84

Qualifying Facility Long-Term Power Purchase Service

TABLE I - SUPPLEMENT #1

THE MONTANA POWER COMPANY
RATE LEVELS FOR LONG-TERM PAYMENT OPTIONS DERIVED IN COMPLIANCE WITH MPSC ORDER NO. 5017 FOR CONTRACT YEAR 1984-1985

	ESCALATING[1]		FULLY LEVELIZED[2]		PARTIALLY LEVELIZED[3]			
					LEVELIZED[2]	ESCL.[1]	LEVELIZED[2]	ESCL.[1]
TERM	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	ENERGY ¢/kWh (ACER)	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	CAPACITY $/kW/YR (ACCR)
4	3.644	56.94	4.124	64.43	2.516	1.421	63.29	1.00
5	3.644	56.94	4.220	65.89	2.574	1.421	64.73	1.00
6	3.644	56.94	4.315	67.33	2.632	1.421	66.14	1.00
7	3.644	56.94	4.409	68.74	2.688	1.421	67.53	1.00
8	3.644	56.94	4.501	70.12	2.744	1.421	68.89	1.00
9	3.644	56.94	4.592	71.47	2.799	1.421	70.22	1.00
10	3.644	56.94	4.680	72.79	2.852	1.421	71.51	1.00
11	3.644	56.94	4.767	74.07	2.905	1.421	72.77	1.00
12	3.644	56.94	4.851	75.31	2.956	1.421	73.99	1.00
13	3.644	56.94	4.933	76.51	3.006	1.421	75.17	1.00
14	3.644	56.94	5.013	77.68	3.055	1.421	76.31	1.00
15	3.644	56.94	5.090	78.80	3.102	1.421	77.42	1.00
16	3.644	56.94	5.165	79.88	3.148	1.421	78.48	1.00
17	3.644	56.94	5.237	80.92	3.192	1.421	79.50	1.00
18	3.644	56.94	5.307	81.92	3.235	1.421	80.48	1.00
19	3.644	56.94	5.375	82.88	3.277	1.421	81.42	1.00
20	3.644	56.94	5.440	83.80	3.317	1.421	82.33	1.00
21	3.644	56.94	5.502	84.67	3.355	1.421	83.19	1.00
22	3.644	56.94	5.562	85.51	3.392	1.421	84.01	1.00
23	3.644	56.94	5.619	86.31	3.428	1.421	84.79	1.00
24	3.644	56.94	5.674	87.06	3.462	1.421	85.54	1.00
25	3.644	56.94	5.726	87.78	3.495	1.421	86.24	1.00
26	3.644	56.94	5.777	88.47	3.526	1.421	86.92	1.00
27	3.644	56.94	5.824	89.12	3.556	1.421	87.55	1.00

(Continued)

Issued ____________ (Date)　By ____________ (Signature of Officer of Utility)

Approved July 2, 1984 (Date)　Effective for services rendered on and after (Date) July 2, 1984

331324/4

(Space for Stamp or Seal of Commission)

PUBLIC SERVICE COMMISSION OF MONTANA

Madeline L. Cottrill
Secretary.

*Space below these lines for use of Commission only.

Form 83-B

Public Service Commission of Montana

E cont.

THE MONTANA POWER COMPANY
(Name of Company)

Sheet No. QFLT-84
Canceling Sheet No. N/A
Page 5 of 5
Supp. #1

Schedule QFLT-84

Qualifying Facility Long-Term Power Purchase Service

TABLE I - SUPPLEMENT #1 (continued)

	ESCALATING[1]		FULLY LEVELIZED[2]		PARTIALLY LEVELIZED[3]			
					LEVELIZED[2]	ESCL.[1]	LEVELIZED[2]	ESCL.[1]
TERM	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	ENERGY ¢/kWh (ACER)	ENERGY ¢/kWh (ACER)	CAPACITY $/kW/YR (ACCR)	CAPACITY $/kW/YR (ACCR)
28	3.644	56.94	5.870	89.73	3.585	1.421	88.16	1.00
29	3.644	56.94	5.913	90.31	3.612	1.421	88.73	1.00
30	3.644	56.94	5.955	90.86	3.638	1.421	89.27	1.00
31	3.644	56.94	5.994	91.38	3.663	1.421	89.78	1.00
32	3.644	56.94	6.031	91.87	3.687	1.421	90.26	1.00
33	3.644	56.94	6.066	92.33	3.709	1.421	90.71	1.00
34	3.644	56.94	6.100	92.76	3.731	1.421	91.14	1.00
35	3.644	56.94	6.131	93.17	3.751	1.421	91.54	1.00

1. These rate levels are subject to annual revision in accordance with MPSC Order No. 5017.

2. These rate levels are fixed for the term of any contract signed during the designated contract year. New rate levels under these payment options are established each year for all contracts signed in such year.

3. See Docket No. 83.1.2, Order No. 5017.

Issued ______________ (Date) By ______________ (Signature of Officer of Utility)

Approved July 2, 1984 (Date) Effective for services rendered on and after July 2, 1984 (Date)

331324/5

(Space for Stamp or Seal of Commission)

PUBLIC SERVICE COMMISSION OF MONTANA

Madeline L. Cottrill
Secretary.

*Space below these lines for use of Commission only.

DRAPES ENGINEERING

BY: SO
DATE: 1-6-85
PROJECT: CONVERSION OF EXISTING BOILER
GREAT FALLS, MONT.
JOB NO. 84-303-02
SHEET 1 OF 2

Exhibit F

DE-M5-73

ITEM NO.	CLASS OF WORK AND MATERIAL	Quantity	Unit	MATERIAL Unit	MATERIAL Extension	LABOR Unit	LABOR Extension	MATERIAL & LABOR Unit	MATERIAL & LABOR Total
	Boilers Modifications								400,000
	Water Cooled Stoker				205,000		30,000		235,000
	Air Preheater								42,500
	Induced Draft Fan				17,500		8,000		25,500
	Multiclone Dust Collector				17,800		4,000		21,800
	Wet Scrubber				63,000		30,000		93,000
	Forced Draft Fan				5,200		2,000		7,200
	Ash Conveyor				333,000		81,000		414,000
	Wood Conveying System				265,500		90,000		355,500
	Combustion Controls								75,000
	Electrical Contract								200,000
	Equipment Enclosure								200,000
	SUBTOTAL								2,069,500
	10% Contingency								207,000
	SUBTOTAL								2,276,500
	12% Contractor P&O								273,180
	SUBTOTAL								2,549,680
	9.5% Design								242,220
	TOTAL								2,791,900

DRAPES ENGINEERING

GREAT FALLS, MONT.

BY SO

DATE 2-6-85

PROJECT NEW BOILER AND TURBINE

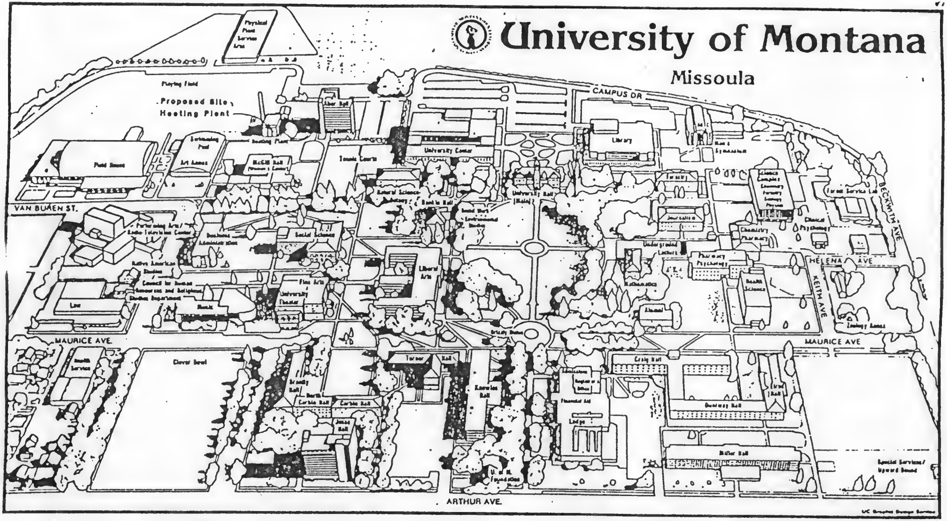
JOB NO 84-303-02

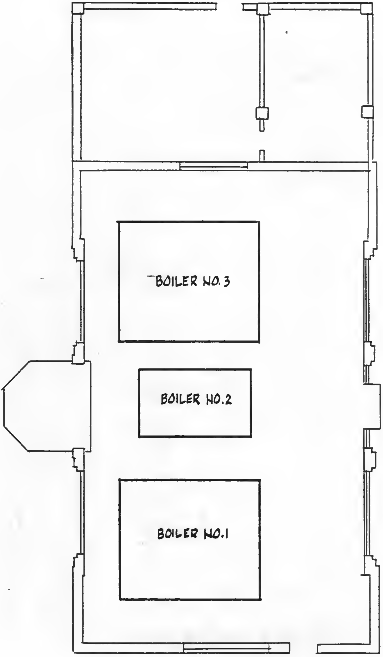
SHEET 2 OF 2

F cont.

ITEM NO	CLASS OF WORK AND MATERIAL	Quantity	Unit	MATERIAL Unit	MATERIAL Extension	LABOR Unit	LABOR Extension	MATERIAL & LABOR Unit	MATERIAL & LABOR Total
	New Boiler 40,000 Pounds Per Hour 600 PSIG. Complete with pollution control equipment, controls, stokers, etc.								1,600,000
	Wood Conveying System				250,000		80,000		330,000
	Ash Conveying System				325,000		70,000		395,000
	Equipment Enclosure								300,000
	SUBTOTAL								2,625,000
	12% Contractor P&O								315,000
	SUBTOTAL								2,940,000
	7% Design								205,800
	10% Contingency								314,580
	TOTAL								3,460,380
	Turbine Complete with Controls and Electrical Interface				1,374,000		50,000		1,424,000
	12% Contractor P&O								170,880
	SUBTOTAL								1,594,880
	7% Design								111,642
	10% Contingency								170,652
	TOTAL								1,877,174
	GRAND TOTAL (BOILER, TURBINE)								5,337,554

DE-MS-73

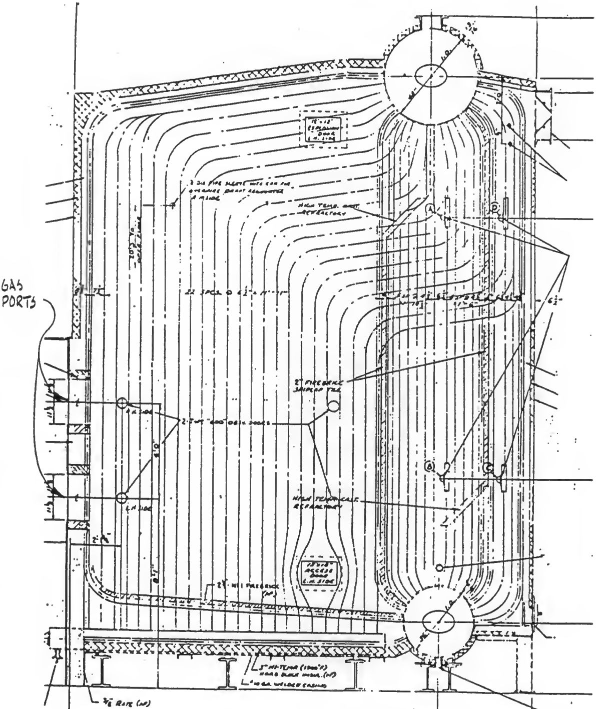

University of Montana
Missoula
Physical Plant Service Area
Playing Field
Proposed Site, Heating Plant
Aber Hall
Field House
Swimming Pool
Art Annex
Heating Plant
McGill Hall (Women's Center)
Tennis Courts
University Center
CAMPUS DR
Library
Men's Gymnasium
Forestry
Science Complex Chemistry Forestry Zoology Physics
Forest Service Lab
BECKWITH AVE
Natural Science Botany
Rankin Hall
Social Work Environmental Studies
University Hall (Main)
Journalism
Chemistry Pharmacy
Clinical Psychology
VAN BUREN ST.
Performing Arts/Radio-Television Center
Business Administration
Social Science
Liberal Arts
Underground Lecture
Pharmacy Psychology
HELENA AVE
Native American Studies
Council for Human Resources and Religious Studies Department
Fine Arts
University Theater
Law
Music
Mathematics
Health Science
KEITH AVE
Alumni
Grizzly Statue
Zoology Annex
MAURICE AVE.
MAURICE AVE
Health Service
Clover Bowl
Turner Hall
Brantly Hall
North Corbin Hall
Corbin Hall
Jesse Hall
Knowles Hall
Craig Hall
Admissions
Registrar's Office
Financial Aid
Lodge
Elrod Hall
Duniway Hall
Miller Hall
U of M Foundation
Special Services/Upward Bound
ARTHUR AVE.
UC Graphic Design Service



FIRST FLOOR PLAN NO SCALE

N

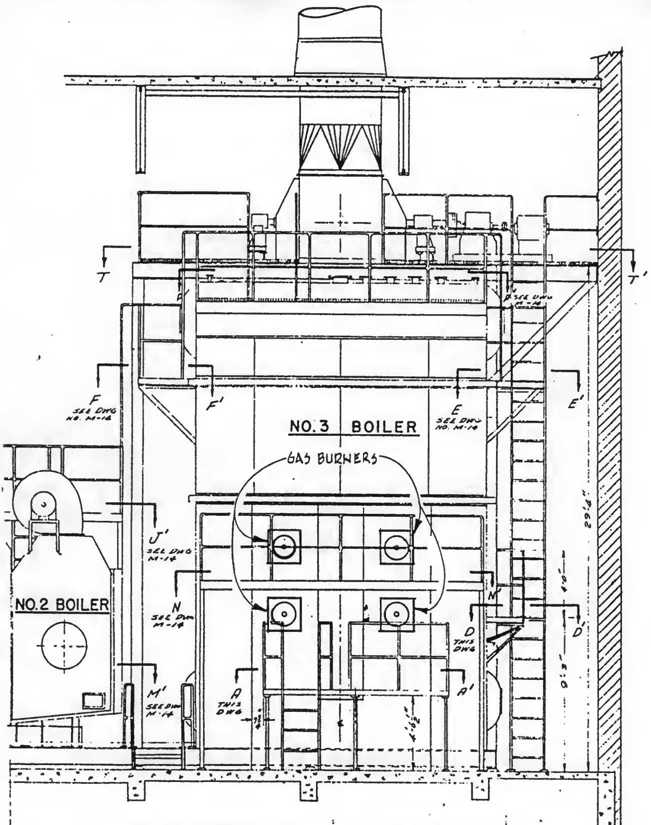
CENTRAL HEATING PLANT U OF M MISSOULA, MONTANA	DRAPES ENGINEERING MECHANICAL & ELECTRICAL ENGINEERS GREAT FALLS, MONTANA	DATE 12-3-84 SHEET 1 OF 1


GAS PORTS
18"x18" EXPLOSION DOOR L.H. SIDE
HIGH TEMP. CAST REFRACTORY
22 SPCS @ 6½" = 11'-11"
2" FIREBRICK SHIPLAP TILE
HIGH TEMP. CAST REFRACTORY
12"x18" ACCESS DOOR L.H. SIDE
2½" NO. 1 FIREBRICK
5" HI-TEMP (1000°F) HARD BLOCK INSUL.
10 GA. WELDED CASING
A
B
C
D
L.H. SIDE
R.H. SIDE

SECTION NO SCALE

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

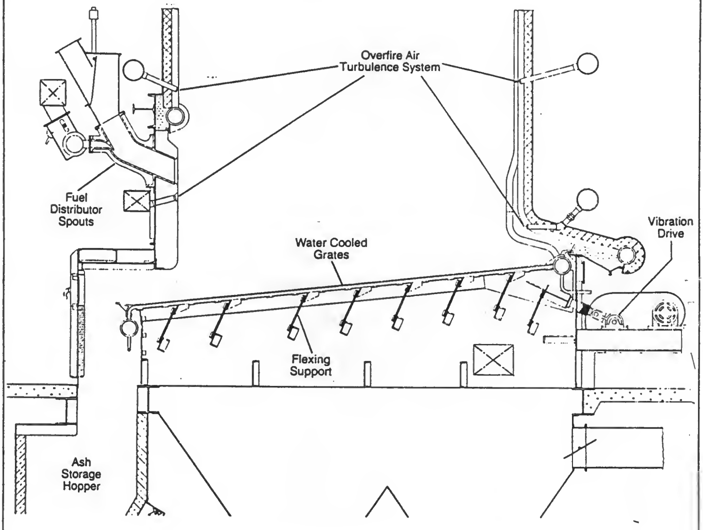
DATE
SHEET
OF



BOILER FRONT ELEVATION NO SCALE

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

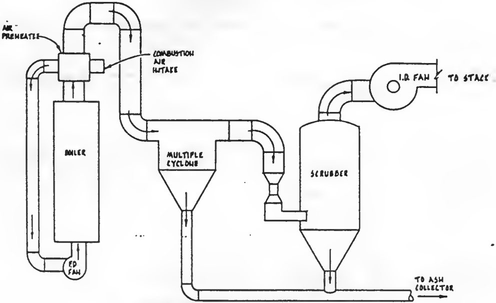
DATE
SHEET
OF



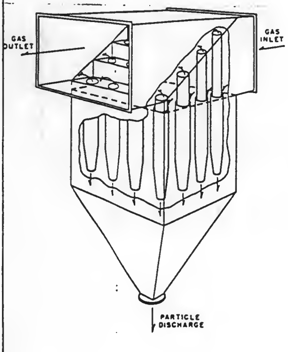
NEW WATER-COOLED GRATE NO SCALE

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

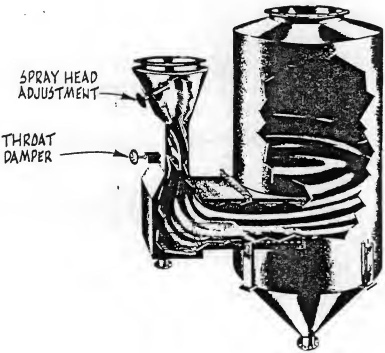
DATE
SHEET
OF



SYSTEM DIAGRAM NO SCALE



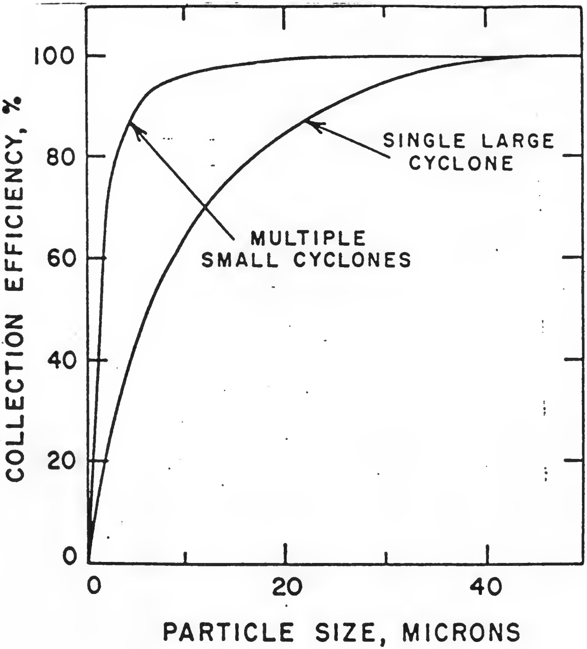
MULTIPLE CYCLONE



SCRUBBER

DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE
SHEET
OF



DRAPES ENGINEERING
MECHANICAL & ELECTRICAL ENGINEERS
GREAT FALLS, MONTANA

DATE	
SHEET OF	

BY SO DATE ______ SHEET ____ OF ____

CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______

PROJECT UM BIOMASS TITLE COGEN. CONTRACT RATES

20 YEAR FULLY LEVELIZED RATE.

Annual Contract Energy Rate = 5.44 ¢/KWH

Annual Capacity Payment = $83.30/KW (Assuming 85% operation)

Effective rate/kwh = $83.30/8760 × .85 = 1.13 ¢/KWH

Total Payment = 5.44¢ + 1.13¢ = 6.57 ¢/KWH

DRAPES ENGINEERING
M/E ENERGY CONSULTANTS
GREAT FALLS, MONTANA

APPENDIX

BY SO DATE ______ SHEET ____ OF ____
CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______
PROJECT U.M. BIOMASS TITLE INFORMATION SOURCES

UNIVERSITY OF MONTANA
BENJAMIN B STOUT DEAN SCHOOL OF FORESTRY
DONALD BREVIK MAINT. SUPERVISOR, HEATING PLANT
JOHN KRE[illegible] PHYSICAL PLANT PLANNING

MISSOULA CITY-COUNTY HEALTH DEPARTMENT
JAMES H CARLSON AIR POLLUTION [illegible]

EQUIPMENT REPRESENTATIVES
ALTERNATE [illegible] & MECHANICAL EQUIPMENT, INC
P.O. BOX 25240
COLORADO SPRINGS, COLORADO 80935-5240 (303) 577-1231
CONTACT · PETER J PERRY
PRODUCTS OFFERED INCLUDE: KEELER DORR-OLIVER BOILER
ASEA-STAL TURBINE GENERATOR, ECONOMIZERS & AIR HEATERS

NORTH ASSOCIATES, INC.
535 SOUTH 3RD WEST
SALT LAKE CITY UTAH 84101 (801) 531-7010
CONTACT RICHARD F NORTH
PRODUCTS OFFERED INCLUDE DETROIT STOKER
CAPITAL CONVEYOR CO., PEABODY PROCESS SYSTEMS (SCRUBBERS)
FANS AND BLOWERS

BY SO DATE ______ SHEET ____ OF ____

CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______

PROJECT U.M. BIOMASS TITLE OPERATION & MAINTENANCE

BASE CASE.

ADDITIONAL O&M COSTS ARE ESTIMATED
TO BE 33% OF THE EXISTING O&M [illegible]
$ [illegible] /MONTH × [illegible] = $ [illegible] /YEAR

CROSS CHECK. 2% OF CONSTRUCTION COST
$ 2,791,900 × .02 = $ 55,335

CROSS CHECK - ADDITIONAL 1.4 MAN YEAR (33% INCREASE) × $20,000 = $ 28,000/YEAR

MATERIALS - HYDROGRATE 5¢/TON × 18,365 TONS = $918	1,000
ASH CONVEYOR	5,000
WOOD CONVEYOR	10,000
	$ 44,000/YEAR

ALTERNATE CASE :

O&M COSTS ARE ASSUMED THE SAME AS THE BASE CASE @ $ 48,000 /YEAR: THE HIGHER WOOD USE IS OFFSET BY THE USE OF ALL NEW EQUIPMENT (INCLUDING THE BOILER)

ADDITION MAINTENANCE FOR THE TURBINE IS ESTIMATED AT 3% OF FIRST COST: .03 × $ 1977,174 = $ 56,000

TOTAL O&M = $ 48,000 + 56,000 = $ 104,000

DRAPES ENGINEERING
M/E ENERGY CONSULTANTS
GREAT FALLS, MONTANA

BY SO DATE ______ SHEET ____ OF ____

CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______

PROJECT U M BIOMASS TITLE ELECTRICAL REQUIREMENTS

ESTIMATE ADDITIONAL ELECTRICAL LOAD FOR BASE CASE CONVERSION

90 KW - LARGER I.D. AND F.D. FANS REQUIRED FOR POLLUTION EQUI
25 KW - WOOD / ASH CONVEYORS, VIBRATING GRATE
115 KW

115 KW × .7 (PART LOAD OPERATING FACTOR) = 80.5 KW
80.5 KW × 8352 ANNUAL OPERATING HOURS = 672,336 KWH
672,336 KWH × $.028/KWH = $18,825 /YEAR

REDUCE 25% FOR ALTERNATE CASE W/ SMALLER NEW BOILER
$18,825 × (1-.25) = $14,119 /YEAR

DRAPES ENGINEERING
M/E ENERGY CONSULTANTS
GREAT FALLS, MONTANA

BY SO DATE ______ SHEET ____ OF ____

CHKD. BY ______ DATE ______ REVISIONS ______ DATE ______

PROJECT U M BIOMASS TITLE BASE CASE SAVINGS

TOTAL STEAM OUTPUT WITH BOILER
LOADS OF 0-30,000 POUNDS OF STEAM
WHICH IS 106,995 MLBs, WOOD COULD SUPPLY
AN ESTIMATED 50% 106,995 x .5 = 53,498 MLBs
WOOD CAN SUPPLY ALL OF THE LOAD WITH
OUTPUTS IN THE 30-50,000 POUND/HOUR RANGE = 78,095 MLBs
WOOD CAN SUPPLY THE FIRST 50,000 POUNDS/HOUR
WHEN LOADS ARE GREATER THAN THAT THIS
OCCURS 315 HOURS/YEAR 315 HOURS x 50,000 LBs = 15,750 MLB
TOTAL SAVINGS = 147,343 MLB

$$\text{WOOD REQUIRED} = \frac{960{,}000\ \text{BTU/MLB} \times 147{,}343\ \text{MLB}}{16.5 \times 10^{6}\ \text{BTU/UNIT} \times .7\ \text{EFF'C}}$$

= 12,244 UNITS

NATURAL GAS SAVED:
FROM PHYSICAL PLANT LOGS 246,635 MCF WERE
REQUIRED TO PRODUCE 203,395 MLB → 1.2126 MCF / MLB

SAVINGS = 147,343 MLB × 1.2126 = 178,668 MCF
178,668 MCF × $4.48 /MCF = $800,433

APPENDIX C

MILESTONE 3

AVAILABILITY OF BIOMASS

APPENDIX C

Availability of Biomass

The engineering report considers (1) conversion of 72 percent of the natural gas-fired heating system at the UM to the use of biomass and (2) the construction of a cogeneration system. The annual requirement for biomass units to supply the conversion is 12,244 units and to supply the cogeneration is 20,041. LEF has in operable stands for thinning a 25-year supply for the conversion and a 15-year supply for the cogeneration, ignoring growth. This document reports how these figures were determined. LEF is operated by the Montana Forest and Conservation Experiment Station, a part of the University of Montana.

The basis for calculations of production potential is in units of 200 ft^3 of hog ful. A unit has approximately 75 ft^3 of solid wood. The engineering report assumes the wood will have a 50 percent moisture content when it is delivered to the boiler. The expected Btu output per unit at that moisture content is about 16.5 million Btu.

Over 2000 acres have been thinned experimentally at LEF in the last eight years. Yields of 10 to 30 units per acre resulted from thinnings in second-growth stands. Overall average yield is 16 units per acre when canopy coverage has been at least 50 percent. Estimates are based only on stands that have a coverage of at least 50 percent.

To estimate as conservatively as possible, future growth on the stands was ignored. LEF's 26,626 forested acres are growing at an estimated minimum average rate of 0.5 units per acre, per year (about 40 ft^3 of solid wood). That approximately equals the energy necessary for the conversion alternative. LEF is constantly working to increase the growth rate. In other regions, 50 percent increases in growth rate have been achieved.

LEF has 21,595 acres on slopes of 45 percent or less (a map is on file at DNRC) with 50 percent crown coverage. Of that total 2,450 acres have been treated recently in one way or another. Therefore, the acreage available to supply biomass from thinnings is 19,145. Thinnings remove only excess stems in a stand. Thinned stands are in better condition after thinning than before.

The engineering report shows that 12,244 units of biomass would be needed annually to fuel the converted heating plant. At 16 units per acre from thinnings approximately 765 acres would be thinned each year to produce that much fuel. LEF's 19,145 acres would provide fuel for 25 years, ignoring annual growth. To supply the cogeneration alternative would require thinning 1252 acres annually; so LEF's 19,145 acres would provide a 15-year supply for cogeneration.

Looking at supply on hand and dividing annual consumption into that is the most conservative way to estimate supply. A more realistic way is to compare annual growth to annual requirements. The largest fuel demand would be for the congeneration alternative; requiring some 20,041 units yearly. Fuel volumes per acre vary, as do growth rates; nevertheless the average growth rate is 0.5 units/acre/year for LEF. Assuming 24,000 acres of average quality land in LEF, the growth is currently 12,000 units per year. This would be the long-term supply. If research increases yield to 0.75 units/acre/year the long-term supply would be 18,000 units per year. In any event, LEF now has a supply of 300,000 units of thinnable material that would supply the cogeneration alternative for at least 15 years.

The foregoing scenario would commit LEF to a desirable role for a forest managed primarily to produce wood. However, LEF has many roles and it would be unwise to commit LEF to only producing biomass to heat UM. In fact, such a sole use could be contrary to stipulations by LEF's donor. A decision would have to be made as to the actual amount that should be committed from LEF.

LEF and private forest landowners, have a plentiful supply of wood for either the conversion or the cogeneration alternative.

APPENDIX D

MILESTONE 4

BIOMASS FEASIBILITY STUDY

BIOMASS FEASIBILITY STUDY

Milestone 4 Report

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Location: Missoula, Montana

Funding: Project Cost--$33,570; Grant--$25,320

Project: Examine the legal, environmental, biological and economic feasibility of using biomass from the University's Lubrecht Experimental Forest (LEF) to heat and light the University. The energy to be used is wood from thinnings in second-growth conifer forests on LEF and other private or state owned lands.

Abstract:

A legal and environmental study was conducted to determine the feasibility of burning wood to heat the University of Montana. Woodburning technology is such that the process can be effected with the emission of essentially zero carbon monoxide (CO) or particulates. This was a critical finding. Missoula is in non-compliance with regard to EPA-set CO levels at certain times.

Conversion of an existing boiler and the construction of a new cogeneration plant were the alternatives considered. Because of University energy demand patterns and the fact that boiler conversion does not permit cogeneration, the cogeneration alternative appears the most opportune.

The LEF has a supply of biomass that could if necessary provide the cogeneration plant for 15 years without considering forest growth. An alternative to total supply from LEF is suggested. The LEF would supply one-quarter of the annual requirements and purchase the remaining three-quarters from state and private non-industrial owners. Such an arrangement would assure a supply for essentially into perpetuity and also spread the benefits with others.

SYSTEM DESIGN SUMMARY

The details of the proposed cogeneration plant are to be found in the Milestone 2 report submitted by Drapes Engineering.

The essence of the report:

Build a cogeneration plant adjacent to the existing heating plant at the University. The proposed plant would cost an estimated $4,412,600. It would be capable of providing 89% of the steam requirements and have the capacity to produce 1200 KW of electricity and up to 40,000 pph of 600 psi steam.

A benefit not apparent in any of this is that the University would keep intact its existing boiler system and could use it in an emergency.

The requirements of the system for wood are estimated to be 20,041 units of biomass. (A unit is 200 cubic feet of chipped wood with an energy content of 16.5 million BTU's at 50% moisture.)

Using the system and selling the electricity could result in a gross savings of $1,242,778 per year. Depending on wood cost, the net savings might range from a quarter to three quarters of $1 million per year.

FUEL SUPPLY

The LEF has on hand 300,000 units of biomass in operable second growth stands. Growth is estimated at 0.5 units per acre per year on those stands when they are intensively managed.

There are in Missoula County, 150,000* acres of private, non-industrial forest acres and 79,000 acres of state land. The total growing stock on both ownerships is estimated to be 370,000,000 cubic feet of solid wood. Seventy-five cubic feet of solid wood equals one 200 cu. ft. unit of chip biomass. Therefore, the growing stock is equivalent to an estimated 5,000,000 units of biomass. Approximately one half of that could be available from thinnings and improvement cuttings, assuming a market.

The LEF is an experimental forest with a broad assignment. While it could supply the entire requirement for a time, that seems unwise and perhaps in violation of the spirit and the legal constraints of the original donor. An alternative is proposed.

Out of its on-going research, demonstration and management work the LEF can supply at least 5,000 of the 20,041 units required annually. The remaining, 15,041 would be obtained by the LEF and delivered to the University with LEF acting as the broker. The 5,000 units would be in effect an intra-University transfer and the 15,041 a quasi-commercial venture. Assuming that such an arrangement can be developed, and based on the apparent supply on private non-industrial forests, state land and other sources,there is an ample supply of wood. We have excluded, just to be conservative, industrial and federal (USFS, BLM, BIA) land. I am told that BLM would be interested in a thinning-biomass program.

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*These data on acreages and volumes have been extracted from two sources: Timber Resources of Mineral, Missoula, and Ravalli Counties. Dept. of State Lands, Division of Forestry. 1983; and from microfiche at the Division of Forestry, Missoula. We thank them for their cooperation.

Basic economic theory says that supply and price are intimately related. We have seen above that the supply is more than adequate. Whether it can be delivered to Missoula will depend largely on price.

Based on operating costs that have been experienced in recent years for thinnings and based on the increases in costs that would be incurred were the above scenario of supply (5000/15041) to become operational, it is estimated that LEF could supply the wood at a 1984 price of $47 per unit ($941,927/yr.). The costs involved are marking, cutting, chipping, hauling, roading, stumpage, supervision, brokering and ash redistribution.

The gross saving of $1,242,778 would be reduced to a net of $300,851 after paying for the wood cost of $941,927. More importantly the $941,927 would contribute to building the Montana economy more than purchasing natural gas.

The technical, managerial and institutional issues that need to be resolved are in the latter category. There are several: (1) Can the LEF operate as the broker? (2) How does the State/Board of Regents/University capture the opportunity that appears to exist? (3) How does the University benefit after the new plant is paid for? Perhaps the savings could be shared: between the general fund and the University and between the University and the School of Forestry. (4) The issue of the sale price of cogenerated electricity is now being discussed. The project should be re-evaluated when a firmer price is set.

GRANT ADMINISTRATION

Once the contract agreement was finally executed the project moved forward in a timely fashion.

The budget has been extremely tight. The tendency has been to expect more than has been bargained for, particularly for the engineers. The subcontractor's problem was that the companies they had to contact to get Code A cost estimates wanted considerably more than the total grant amount to provide the necessary information.

Budget

	DNRC	UM (in kind)
Salaries & Benefits	$11,600	$9,400
Contracted Services	8,000	
Indirect	4,220	
Travel	1,500	
TOTAL	$25,320	$9,400

CONCLUSIONS AND RECOMMENDATIONS

1. It is legally and environmentally feasible to provide up to 89% of the University's heat requirement using biomass and produce cognerated electricity.
2. A wood supply exists to meet the requirements. Part of the supply would come from LEF and part from private non-industrial, state land and other sources.
3. With an investment of an estimated $4,412,600, the cost of heating the University using biomass while doing cogeneration could amount to a savings of $300,000 per year.

4. It is recommended that the University, Board of Regents and appropriate Executive and Legislative Offices be apprised of this opportunity when the DNRC accepts this report.

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